Next-Generation Bioacoustic Analysis Software

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LONG-TERM GOALS

In the past two decades, awareness has grown that acoustic methods are often the best means for studying and monitoring marine mammals. Acoustic methods, for instance, have long been used for detection and study of sperm whales, in part because of the difficulty of visual detection: Visual surveys have been estimated to miss 38% of sperm whales that are on a ship's trackline (Barlow and Rankin 2004), and more at greater distances from the trackline. Other species are similar or worse; for instance, it is estimated that approximately 85% of Cuvier's beaked whales on the trackline are missed with visual scanning (J. Barlow, pers. comm). Acoustic methods, in contrast to visual ones, function well in darkness, fog, high sea states, and other inclement viewing conditions. Via the use of autonomous recorders, acoustic methods can also be used in remote or inhospitable areas (Širović et al. 2004, Mellinger et al. 2008) where visual monitoring would be impracticable or impossible. Software tools are needed for analyzing such data sets, even for such simple tasks as manually scanning spectrograms to find calls of interest. Acoustic localization of calling animals is often performed; whether estimates are in one dimension (bearing), two (X-Y position), or three (X-Y-Z position), analysis software is necessary. Marine mammal acoustic data is often collected in very large data sets, necessitating automated methods for data analysis. For instance, AURAL autonomous recorders (Multi-Électronique, Inc.) operate at a sample rate of 32 kHz, so that a one-year data set is 2 terabytes (TB) in size. Another type of autonomous recorder, the HARP (Wiggins 2003; J. Hildebrand, pers. comm.), operates at even higher sample rates – up to 200 kHz – making a one-year data set 12.6 TB in size. Automation tools are clearly needed for data sets of this scale.

Starting in 2000, ONR funded the development of one such tool, Ishmael (Mellinger 2001). It is a user-friendly bioacoustic analysis package for Windows. It includes displays of sound waveforms and spectrograms, recording capability for real-time input, several methods for acoustic localization, beamforming, several methods for automatic call recognition, and a sound annotation facility. Ishmael is aimed at users wishing to analyze large volumes of data quickly and easily. Ishmael quickly became popular, with thousands of downloads by users; a large proportion those downloads were in active use, and a survey in 2005 showed that 46% of respondents use it regularly. It has also been used in much ONR-funded research.

In this project, we have implemented a number of improvements and updates to Ishmael.

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OBJECTIVES

- Hire and train a software engineer to make improvements to Ishmael.
- Implement new audio I/O.
- Implement improved localization.
- Implement improved detection and classification.
- Implement improved acoustical measurements.
- Implement programming interfaces.
- Update Ishmael's documentation for these improvements.
- Create user group / web site for users to share information and tips.

APPROACH

The approach is to hire a software engineer to perform most of that above tasks in collaboration with myself. Research assistants will also perform much of the updating of documentation. The software engineer, Jonathan Dodge, has been working on implementing a number of improvements this year.

WORK COMPLETED

The software engineer, Jonathan (Jon) Dodge, was hired and started work on Ishmael in early December 2010. Training began immediately by my showing him how Ishmael worked, what classes and data structures it uses, how it interfaces to Windows and to the world, etc. The training period ended gradually, and Jon has now implemented a number of major changes to Ishmael.

To date, Jon (with occasionally assistance from me) has done the following:

- Implemented a user-friendly filtering system, which allows users to filter their sounds using low-pass, high-pass, band-pass, and band-stop filters. This allows users to remove portions of the spectrum with unwanted sounds. Filtering also allows re-sampling, so that users can convert their files to a lower sample rate (or, more rarely, a higher sample rate if desired).
- Implemented a major new system for noise-resistant acoustical measurements. These measurements are made after subtracting background noise, and they are computed using features that are relatively resistant to noise. For instance, instead of measuring low and high frequency, in this system one measures centroid frequency and variance in frequency, each weighted by the amount of acoustic energy present at each frequency. Unlike low/high frequency bounds, these values that do not change much when a higher level of background noise masks fainter parts of the signal.
- Fixed a longstanding problem in Ishmael's real-time acquisition in which samples would be dropped. This caused data loss, and had the side effect that Ishmael's time-stamped files gradually fell behind real time.
- Made Ishmael compatible with another new version of the development environment (Borland/Embarcadero).

- Kept Ishmael operating successfully on Windows 7 (both 32-bit and 64-bit) and Mac OS X.
- Fixed a number of bugs: Null pointer exceptions, which would cause Ishmael to crash; creation of detection windows off-screen, rendering them invisible to the user; new memory leaks, which would cause Ishmael to gobble up ever-increasing amounts of memory; and several more minor bugs.

RESULTS

Ishmael has several new features, most prominently filtering and the measurement system.

The new version of Ishmael, Version 2.3, has been put on the web site (http://www.bioacoustics.us/ishmael.html) and was used for SeaBASS at Penn State and the *Introduction to Detection, Classification, and Localization* tutorial at the Mt. Hood DCLDE workshop. A poster and live demonstration was given at the Mt. Hood DCLDE workshop; the abstract for this is as follows:

Dodge, J., D.K. Mellinger, H. Klinck. 2011. Ishmael 2.0: An improved software package for detection and localization of marine mammal vocalizations. Book of Abstracts, Fifth International Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics, 21-25 August 2011, Mt. Hood, Oregon, p. 70.

IMPACT/APPLICATIONS

Ishmael is used for marine mammal acoustic monitoring in many places around the world. Having the new features should make it more useful to researchers everywhere.

RELATED PROJECTS

Advanced Methods for Passive Acoustic Detection, Classification, and Localization of Marine Mammals (award numbers N0001411IP20086 and N0001411WX21401). This ONR-funded effort is developing improved algorithms that will be offered to users in a user-friendly way by implementing them in Ishmael in the future.

Ishmael was used to teach the tutorial *Introduction to Detection, Classification, and Localization* at the Mt. Hood DCLDE workshop (N00014-11-1-0197).

Ishmael is used in the Marine Bioacoustics Summer School (SeaBASS; N00014-12-1-0210)) in June 2012 to teach detection, classification, and localization.